After the commencement of fission the follicle may contain numerous egg-like cells, which are probably identical with the giant cells which I have previously described in the ovicell of *Crisia*. Although it is not impossible that these cells may play some part in the formation of the secondary embryos, this is rendered improbable, not only by the analogy of *Crisia*, but still more by the fact that the early stages in the development of the primary embryo take place before such cells can be recognised in the ovicell.

The following results may be deduced from the preceding statements:—

1. The ovicell is not altogether external to the zoœcia, as might be inferred from some of the older descriptions of this structure. Its cavity is morphologically identical with the body-cavity of the zoœcia, and the ovicell results from the breaking down of numerous septa which at first separate from one another a set of tubes formed at the growing edge of the colony in the same manner as the ordinary zoœcia.

2. The development of the ovicell and that of the embryo normally commence at almost the beginning of the life of the colony. So long as the growth of the first brood of larvæ continues there is no development of new primary embryos; and the numerous young larvæ found in the ovicell are descendants of the single primary embryo which is normally produced in one of the two zoœcia first budded off from the primary zoœcium.

3. The process cannot well be interpreted as a form of alternation of generations. A large number, perhaps the great majority, of the secondary embryos are formed by the direct fission of pre-existing embryos, and are not budded off from a compact mass of cells as in *Crisia*.

4. Certain remarkable analogies may be detected between the development of the Cyclostomata and that of the Phylactolæmata. Further research will be necessary in order to show whether these resemblances are more than mere analogies.

IV. "The Influence of the Force of Gravity on the Circulation."

By LEONARD HILL, M.B., Assistant Professor of Physiology, University College, London, and Grocers' Research Scholar. Communicated by Professor SCHÄFER, F.R.S. Received November 19, 1894.

(From the Physiological Laboratory of University College, London.)

(Abstract.)

The effect of position of the body upon the circulation of the blood is a matter of daily observation with the physician and surgeon, but

it has been curiously neglected by physiologists. So far as my researches into the history of the subject go, the mere fact that the feet-down position lowers arterial pressure, and that the feet-up position heightens it, is almost all that has been determined.

In 1885, Hermann placed the subject in the hands of two pupils, Blumberg and Wagner, with the object of investigating the dynamic and hydrostatic effects of gravity on the circulation.

The hydrostatic moment is the altered relationship of level between the given spot on the artery (where the manometer is placed) and the rest of the vascular system.

The dynamic moment is the altered relation between pressure and resistance produced indirectly by the change of position on the heart-beat, the filling of the heart, the vaso-motor nerves, &c.

Hermann instructed his pupils to find the indifferent point of the circulatory system, in order that the hydrostatic effect might be eliminated and the dynamic effect alone studied.

Blumberg and Wagner determined the indifferent point by filling the circulatory system of the dead animal with salt solution and then by shifting the position of the axis round which the body was turned.

I have found that on attempting, according to Wagner's method, to fill the circulatory system of the dead animal with salt solution, the arterial part of the system does not remain filled, for the salt solution rapidly leaks into the splanchnic venous area. By alternately placing the animal with feet down or with feet up, a pumping action is produced which gradually forces the salt solution out of the arterial system into the venous side, where it remains. The indifferent point cannot, therefore, be found on the dead body. Further, if it were possible to find the indifferent point on the dead body, the indifferent point on the living body could not be deduced therefrom, because such indifferent point depends on the coefficient of elasticity which must constantly alter in the living animal with every alteration of the arterioles by vaso-constriction or dilatation.

As regards the dynamic effect of gravity on the circulation, therefore, the work of Blumberg and Wagner cannot be accepted.

My attention was first drawn to the influence of gravity upon the circulation by observations which I made upon the normal intra-cranial tension in a patient of Dr. Claze-Shaw. This patient had been trephined, and Dr. Shaw asked me if I could estimate his normal intra-cranial pressure. I did so by an adaptation of the method for investigating intra-cranial pressure described by me in the 'Proceedings of the Royal Society,' vol. 55.

I found that the pressure was negative while the man sat upright, but that it became positive as soon as the head was bent down towards the knees, and on any expiratory effort. The air-

bubble index in the apparatus exhibited large cardiac and respiratory undulations.

Experimenting on dogs, I found that exactly the same thing occurred. The normal cerebral pressure became markedly negative in the feet-down posture, and positive in the feet-up posture.

For the further investigation of the subject, I constructed an animal holder which could be swung round a horizontal axis. In this axis the cannula connected with the vessel under observation was always placed, and the cannula itself was connected with a fixed hydrostatic manometer.

The "hydrostatic and dynamic moments," to use Hermann's expression, were investigated and separated, not by attempting to find the indifferent point, but by carefully observing the effects of dividing and stimulating the vagus and splanchnic nerves and spinal cord, and by watching the influence of anæsthetics, curare, and asphyxia.

The research has been carried out upon rabbits, cats, dogs, and monkeys, and the same general results have been obtained from all. The animals were anæsthetised in all the experiments, and were placed upon a board with the limbs fully extended in the same direction as the longitudinal axis of the body.

The experiments group themselves under the following headings:

A. Effects on the Circulation.

i. Normal effect on arterial pressure.
  (*a*) With carotid artery in axis.
  (*b*) With femoral artery in axis.
  (*c*) With splenic artery in axis.
ii. Normal effect on venous pressure.
  (*a*) With splenic vein in axis.
  (*b*) With femoral vein in axis.
  (*c*) With torcula Herophili in axis.
iii. Influence of anæsthetics.
iv. Effect of dividing the vagi.
v. Effect of dividing the spinal cord.
  (*a*) Influence on heart.
vi. Effect of dividing the splanchnics.
vii. Influence of respiration and asphyxia.
viii. Influence of curare.

B. Effects on Respiration.

i. Normal effects.
ii. Effect of dividing the vagi.

The venous pressures were recorded by means of a manometer filled with sat. $MgSO_4$ sol. and placed in connection with a delicate

tambour or piston recorder. The cerebral venous pressure was taken in the torcula Herophili by the method described by me in the before-quoted paper.

The respiratory tracings were taken by means of a broad band of strapping passed round the thorax and connected to either side of a Paul Bert tambour. The changes of position prevented the use of any more accurate method for recording the respiration.

The results of the research are shown in a series of tracings, from which the following conclusions are drawn:—

1. That the force of gravity must be regarded as a cardinal factor in dealing with the circulation of the blood.
2. That the important duty of compensating for the simple hydrostatic effects of gravity in changes of position must be ascribed to the splanchnic vaso-motor mechanism.
3. That the effects of changing the position afford a most delicate test of the condition of the vaso-motor mechanism.
4. That the amount of compensation depends largely on individual differences.
5. That the compensation is far more complete in upright animals such as the monkey, than in rabbits, cats, or dogs, and, therefore, is probably far more complete in man.
6. That in some normal monkeys over-compensation for the hydrostatic effect occurs.
7. That in the normal monkey and man gravity exerts but little disturbing influence, owing to the perfection of the compensatory mechanism.
8. That when the power of compensation is damaged by paralysis of the splanchnic vaso-constrictors, induced by severe operative procedures or by injuries to the spinal cord, by asphyxia, or by some poison such as chloroform or curare, then the influence of gravity becomes of vital importance.
9. That the feet-down position is of far greater moment than the feet-up position, because when the power of compensation is destroyed the blood drains into the abdominal veins, the heart empties, and the cerebral circulation ceases.
10. That, generally speaking, the feet-up position occasions no ill consequence.
11. That the horizontal and feet-up positions at once abolish the syncope induced by the feet-down position by causing the force of gravity to act in the same sense as the heart, and thus the cerebral circulation is renewed.
12. That firmly bandaging the abdomen has the same effect. While the heart remains normal, and so long as the mechanical pressure is applied to the abdominal veins, the blood pressure cannot possibly fall.

13. That if the heart is affected, as by chloroform or curare poisoning, the restoration of pressure is incomplete, and it is possible that the heart may be stopped altogether by the inrush of a large quantity of blood, caused by too rapid an application of pressure on the abdomen. More work would be thrown upon the heart than, in its impoverished condition, it could perform.
14. That vagus inhibition and cardiac acceleration are subsidiary compensatory mechanisms in the feet-up and feet-down positions respectively.
15. That chloroform rapidly paralyses the compensatory vaso-motor mechanism, and damages the heart.
16. That ether, on the other hand, only paralyses the compensatory vaso-motor mechanism very slowly and when given in enormous amounts.
17. That the vaso-motor paralysis induced by these anæsthetics lasts for some considerable time after the removal of the anæsthetics.
18. That chloroform can, by destroying the compensation for gravity, kill the animal, if it be placed with the abdomen on a lower level than the heart.
19. That elevation or compression of the abdomen immediately compensates for the vaso-motor paralysis produced by chloroform.
20. That compression or elevation of the abdomen, coupled with artificial respiration and with squeezing of the heart through the thoracic walls, is the best means of restoring an animal from the condition of chloroform collapse. That these results agree entirely with McWilliams', and are opposed to those of the Hyderabad Commission.
21. That the feet-down position inhibits respiration, and the feet-up position accelerates it.
22. That these respiratory results probably depend upon the stimulation of sensory nerve endings by changes of tension brought about by the alterations of position, because the results are abolished by dividing the vagi.
23. That in the feet-down position the respiration is thoracic in type, and the abdomen is retracted; in the feet-up position the respiration is diaphragmatic and the abdomen freely expanded.
24. That these types of respiration tend to compensate for the effects of gravity on the circulation, for the retraction of the abdomen in the feet-down position mechanically supports the abdominal veins, whilst the thoracic inspirations aspirate blood into the heart. In the feet-up position the full and free expansion of the abdomen withdraws all obstacles to the compensatory dilatation of the abdominal veins.

In the last part of the paper the medical aspects of this research are discussed. It is suggested that emotional syncope is due to paralysis of the splanchnic area, and a case is quoted where compression of the abdomen immediately removed the syncopal condition. The same treatment, or that of elevation of the abdomen, is suggested for conditions of shock, chloroform collapse, and after severe hæmorrhage.

Finally, a parallel is drawn between some of the results of this research in reference to monkeys and those obtained by Dr. George Oliver on man, by measuring the diameter of the radial artery with his ingenious instrument, the arteriometer.

The Chairman announced that a paper on a newly-discovered gas having been promised by Lord Rayleigh and Professor Ramsay, this paper would on January 31 be taken as a subject for discussion under a Resolution of Council passed last session, whereby in each year certain Ordinary Meetings were to be "devoted each to the hearing and consideration of some one important communication, or to the discussion of some important topic."

The Society adjourned over the Christmas Recess to Thursday January 17, 1895.

Presents, December 13, 1894.

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